REDUCE
REUSE
RECYCLE

Environment
Environnement
Ontario

OZONE-DEPLETING SUBSTANCES

Located in the upper reaches of the atmosphere, the ozone layer is the earth's protective shield against harmful ultraviolet radiation from the sun. Over the past 20 years, however, the ozone layer has shrunk by an estimated one to three per cent, mainly because of the effect of certain man-made ozone-depleting substances. In the mid-1980s, scientists noticed that the ozone layer over the Antarctic was depleted by more than 50 per cent for about three months of the year. A similar "hole" in the ozone layer was recently discovered over the Arctic.

Without the protection of the ozone layer, the sun's ultraviolet rays would cause significant harm to animal and plant life, and an increase in the incidence of skin cancer and cataracts in humans.

Ironically, ozone created at the ground level is a serious air pollutant that can damage human health and agricultural crops in, or near, large urban areas. It is formed from automobile exhausts and gasoline vapors which collect over cities on hot summer days. Ground-level ozone pollution, however, is an environmental problem quite different from ozone-layer depletion.

Ozone-depleting Substances

Ozone is created from the effects of high energy ultraviolet solar radiation on oxygen (O_2) molecules. The oxygen molecules are broken down into very active individual oxygen atoms known as "free radicals". A free oxygen radical has a tendency to combine with another oxygen molecule to produce ozone.

$$O_2 \xrightarrow{\text{ultraviolet radiation}} O + O$$

$$O + O_2 \longrightarrow O_3$$

Ozone production takes place mainly above the equator. High-level atmospheric winds then carry the ozone around the earth. The resulting ozone layer is about 20 kilometres thick, and lies between 15 to 50 kilometres above the earth's surface. The peak concentration of ozone is about 25 kilometres above the ground. However, because it is so dispersed, if the ozone were compressed to sea-level pressure, the ozone layer would only be 3 millimetres thick.

As ozone is created by ultraviolet rays, it is also destroyed when it combines with the free radicals of hydrogen, chlorine and nitrogen compounds, which have similarly been released by the effect of ultraviolet radiation in the upper reaches of the earth's atmosphere. This is a natural process. But the balance between ozone creation and ozone depletion is upset by human activities, such as the emission of jet airplane exhausts, the burning of fossil fuels, and most of all, by the release of chlorofluorocarbons (CFCs) and halons.

CFCs are a family of long-lasting synthetic chemicals that contain carbon, chlorine, fluorine and sometimes hydrogen. They were developed about 60 years ago as a substitute for ammonia in refrigerators. CFCs continue to be used as coolants in refrigerators and air conditioners as well as blowing agents in foam product manufacturing, as cleaning solvents for electrical components, as slurries in aerosol sprays, and in hospital sterilization procedures.

World production of CFCs is around 700,000 tonnes a year. About 20,000 tonnes of CFCs are produced in Canada annually. Ontario accounts for about half of Canada's total CFC consumption.

Halons are also ozone depleting chemicals. Relative to CFCs, halons are a group of chemicals that contain bromine. They are used almost exclusively in fire protection applications.

CFC Applications in Canada, 1987	As Percentage of Total
Coolants in refrigerant and air-conditioning equipment	33
Blowing agents in foam-product manufacturing	44*
Cleaning solvents for electronic components, dry cleaning, metal cleaning	9
Aerosol applications	11*
Miscellaneous	3

* Aerosol products and rigid packaging foams in Ontario no longer utilize CFCs as propellants or as blowing agents.

Once released from the products and processes where they are used, CFCs and halons rise up into the upper atmosphere where, because they are stable chemicals, they persist for a long time. Eventually, however, they break down into their constituent elements. Chlorine, fluorine and bromine released from this process deplete the ozone layer and permit increased amounts of ultraviolet radiation to reach the earth's surface.

In the 70-100 years that it remains active, one atom of chlorine (Cl) can destroy 100,000 molecules of ozone.

$$CFCl_3{}^{*} \xrightarrow{\text{ultraviolet radiation}} CFCl_2 + Cl$$

$$Cl + O_3 \longrightarrow ClO + O_2$$

$$O + ClO \longrightarrow Cl + O_2$$

* Also known as CFC-11 (trichlorofluoromethane)

The harm that a chemical can do to the ozone layer is based on a concept known as "ozone-depletion potential" (ODP). Higher ODP values indicate greater potential to damage the ozone layer. There are many different kinds of CFCs, with varying ODP levels. An ODP value of 1.0 is assigned to CFC-11 (trichlorofluoromethane). All other ODP values are assigned relative to CFC-11.

How CFCs and Halons are Released into the Atmosphere

The release of ozone-depleting CFCs from refrigerators and in domestic, commercial and mobile air conditioners can be caused by leaks as well as during installation and servicing.

CFCs, which are used as blowing agents in the manufacture of rigid packaging foam (typically used for packaging food items) and flexible foam products (typically used for seat cushions and automobile dashboards), are released during or immediately after the production process. Most rigid insulation foams retain 90-95 per cent of the CFCs used in production, but as it starts to age, the CFCs are dispersed into the air.

CFCs are also emitted into the atmosphere as aerosol propellants and slurries used in various spray products. In Ontario, CFCs have been banned for use in all aerosol sprays, with the exception of prescription drugs and limited special applications.

Finally, CFCs are released through evaporation of solvents used for precision-parts cleaning and drying of electronic circuitry, in metal cleaning, and the dry cleaning of clothes.

The majority of halons are "banked" in building fire-protection systems and portable fire extinguishers. The chief sources of halon emissions are the testing of this equipment.

Ozone Depletion Potential (ODP) Values of Chlorofluorocarbons and Halons

Type	*Application*	*ODP*
CFC-11	Propellant, refrigerant, cleaning solvent, blowing agent	1.0
CFC-12	Propellant, refrigerant, blowing agent	1.0
CFC-113	Refrigerant, cleaning solvent, blowing agent	0.8
CFC-114	Propellant, refrigerant, blowing agent	1.0
CFC-115	Refrigerant, blowing agent	0.6
Halon-1211	Fire-protection equipment	3.0
Halon-1301	Fire-protection equipment (portable)	10.0
Halon-2402	Fire-protection equipment	6.0

Control Measures

Measures to control CFC and halon emissions have been developed through years of extensive international negotiations. Some of these measures have been incorporated into the laws of individual countries.

Action to protect the ozone layer was initiated by the United Nations Environment Programme (UNEP) in 1977. Three years later, a number of countries, including Canada, prohibited the use of CFCs as propellants in aerosol spray for personal care products.

UNEP subsequently initiated negotiations aimed at the development of a global convention to protect the ozone layer. In 1985, the Vienna Convention for the Protection of the Ozone Layer was signed by 22 countries. The convention covered international co-operation in research, but did not contain any agreement on controls.

After several more years of negotiation, an agreement was reached by some 40 countries, including Canada, on the protocol and timetable for imposed controls on ozone-depleting CFCs and halons. The agreement was signed in September, 1987, in Montreal, and has since been ratified by about 60 countries.

The "Montreal Protocol for Substances that Deplete the Ozone Layer," came into force on January 1, 1989. By July 1, 1989 all signatory nations were to cap the consumption (defined as "production plus imports, minus exports") of CFCs to 1986 levels. By 1993, CFC consumption would be reduced by 20 per cent, and by 1998, by 50 per cent of 1986 levels. At a meeting in Geneva, Switzerland, in April, 1990, the signatory nations agreed to increase the target levels and to include additional chemicals to the list of ozone-depleting substances. In June 1990, the Montreal Protocol was amended to include all fully halogenated CFCs, 1,1,1-trichloroethane, and carbon tetrachloride. A new phase-out schedule was also adopted.

Ontario was the first province in Canada to pass legislation which supports the intent of the Montreal Protocol. The "ozone-depleting substances" amendment to the Ontario *Environmental Protection Act* prohibited the manufacture and sale of aerosols and foam packaging made with CFCs, effective July 1, 1989. The amendment also set a framework to enable the Ministry of the Environment to prohibit and phase out remaining CFC uses as soon as alternatives are found. The ministry's goal is to reduce Ontario's consumption of CFCs by more than half by 1993. Ontario will continue to regulate other CFCs where technically feasible.

Ontario Phase-out of Ozone-depleting Substances

Aerosols	
Propellants	July 1, 1989
Slurrying Agents	September 1, 19[illegible]
Foams	
Rigid Packaging	July 1, 1989
Flexible Foam	September 1, 1990*
Rigid Insulation	January 1, 1991*
Venting of CFCs in Mobile Air Conditioning Systems	July 1, 1991

* Beginning of phase-out period. Complete ban effective December, 1993 based on commercial availability of alternatives.

Recycling of CFCs

An amendment to Regulation 309 of the *Environmental Protection Act* to facilitate the collection, handling, transportation and recycling of spent refrigerants from commercial and domestic cooling systems became effective September 1, 19[illegible].

The Search for Substitutes

UNEP prepared a series of technical option reports which identify the near and long-term alternatives to CFC uses in all applications. CFC manufacturers have identified alternative chemicals to replace CFCs in specific applications. An international co-operative was founded by CFC manufacturers and has initiated the required toxicity assessments of these chemicals. Associations representing industrial users of CFCs have also joined together to identify and to share information on new technologies for the reclamation, recycling, substitution and destruction of CFCs and halons.

For More Information

To obtain additional copies of this brochure or *The Ontario Phase-out of Ozone-depleting Substances – A Compliance Guide*, call or write:

Public Information Centre
Environment Ontario
135 St. Clair Avenue West
Toronto, Ontario
M4V 1P5
(416) 323-4321

RÉDUIRE

RÉUTILISER

RECYCLER

Environment
Environnement
Ontario

Située dans la haute atmosphère, la couche d'ozone est le bouclier qui protège la Terre contre les rayons ultraviolets du soleil, très nocifs. Toutefois, on estime qu'au cours des vingt dernières années, cette couche d'ozone a rétréci de un à trois pour cent, principalement parce que certaines substances artificielles la rongent. Au milieu des années 1980, des scientifiques ont remarqué qu'au-dessus de l'Antarctique, elle diminuait de plus de moitié pendant environ trois mois de l'année. Récemment, ils ont découvert un «trou» similaire au-dessus de l'Arctique.

Sans la protection de la couche d'ozone, les rayons solaires ultraviolets nuiraient considérablement à la vie animale et végétale, et on assisterait, dans l'espèce humaine, à une recrudescence des cancers de la peau et des cataractes.

Paradoxalement, l'ozone créé au niveau du sol constitue un polluant atmosphérique dangereux qui peut nuire à la santé humaine et endommager les récoltes à l'intérieur ou à proximité des grandes zones urbaines. Il est sécrété par les gaz d'échappement des véhicules et par les vapeurs d'essence qui s'accumulent au-dessus des villes pendant les journées chaudes de l'été. Cependant, la pollution par l'ozone au sol pose un problème environnemental très différent de celui de l'appauvrissement de la couche d'ozone.

L'ozone résulte de l'action des rayons solaires ultraviolets de haute énergie sur les molécules d'oxygène (O_2). Celles-ci se scindent en atomes individuels d'oxygène très actifs dits «radicaux libres». Un radical d'oxygène libre se combine généralement avec une autre molécule d'oxygène pour produire de l'ozone (O_3).

$$O_2 \xrightarrow{\text{rayonnement ultraviolet}} O + O$$

$$O + O_2 \rightarrow O_3$$

La majeure partie de l'ozone est produite au-dessus de l'équateur avant que des vents atmosphériques élevés le transportent autour du globe. La couche d'ozone ainsi obtenue a une vingtaine de kilomètres d'épaisseur et elle flotte entre 15 et 50 kilomètres au-dessus de la surface de la Terre. C'est à quelque 25 kilomètres du sol qu'elle est le plus concentré. Cependant, l'ozone est tellement dispersé que si on le comprimait à la pression du niveau de la mer, la couche formée n'aurait que trois millimètres d'épaisseur.

Tout comme l'ozone est produit par les rayons ultraviolets, il est détruit en se combinant avec les radicaux libres des composés hydrogénés, chlorés et azotés, eux aussi libérés par l'action du rayonnement ultraviolet dans la haute atmosphère terrestre. Il s'agit là d'un processus naturel. Mais l'équilibre entre sa création et sa disparition est bouleversé par des activités humaines telles que l'émission de gaz de combustion par les avions à réaction, la combustion de sources d'énergie fossiles et, surtout, le rejet de chlorofluorocarbones (CFC) et de halons.

Les CFC sont une famille de produits chimiques de synthèse persistants qui contiennent du carbone, du chlore, du fluor et parfois de l'hydrogène. Ils ont été mis au point il y a une soixantaine d'années pour remplacer l'ammoniac dans les réfrigérateurs. On continue de les employer comme frigorigènes dans les réfrigérateurs et dans les climatiseurs, comme gonflants dans la fabrication de mousses, comme solvants de nettoyage pour les composants électroniques, comme suspension dans les aérosols ainsi que dans les procédés de stérilisation en milieu hospitalier.

Chaque année, le monde produit quelque 700 000 tonnes de CFC. Sur ce total, la part du Canada représente près de 20 000, dont l'Ontario consomme une moitié environ à lui seul.

Les halons appauvrissent eux aussi la couche d'ozone. Ces produits chimiques, apparentés aux CFC, contiennent du brome. On les utilise presque exclusivement dans des applications liées à la protection contre les incendies.